Early versus late treatment of crowded first premolar extraction cases: Postretention evaluation of stability and relapse

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The purpose of this study was to evaluate differences in the long-term stability of orthodontically induced changes in arch form between early orthodontic treatment (Hellman's dental age III B, mixed dentition) and late orthodontic treatment (Hellman's dental age III C or after, permanent dentition). The difference in long-term stability of orthodontically induced changes of arch alignment in patients who are treated early and those who are treated late is not well established. Maintenance of mandibular arch alignment is one of the most difficult retention problems facing clinical orthodontists. Long-term stability has been evaluated in a variety of studies,[1-18] but none compare the stability of early versus late orthodontic treatment for maxillary and mandibular first premolar extraction cases. This study investigated these differences using cases that had been out of retention a minimum of 10 years.

Materials and methods

The sample consisted of diagnostic records for 83 patients who were categorized as Class I, Class II Division 1, or Class II Division 2 malocclusions at pretreatment. These cases had complete records and were selected from the University of Washington Department of Orthodontics and from faculty practices in the Seattle area. All cases had pretreatment crowding (moderate irregularity, severe irregularity, or very severe irregularity)[19] of mandibular anteriors and no spacing in the anterior dentition. Patients with anterior openbite and/or posterior crossbite

Abstract

The purpose of this study was to evaluate the differences in the long-term stability of orthodontically induced changes in arch form between patients who receive early orthodontic treatment (Hellman's dental age III B, mixed dentition, n=36) and those who are treated later (Hellman's dental age III C or after, permanent dentition, n=47). Dental casts were evaluated before treatment, after treatment, and at a minimum of 10 years after retention. All patients had received routine edgewise orthodontic treatment that included maxillary and mandibular first premolar extraction. There were no significant differences between these groups at pretreatment and posttreatment. In the majority of cases, some degree of mandibular crowding occurred during the postretention period. There was a significant difference in the mandibular irregularity index at postretention between these groups. Regarding the deviation of the midline of the central incisors, there were no significant differences between these groups at pretreatment and posttreatment, but there was a significant difference at postretention. At the postretention stage, the late treatment group had greater mandibular anterior irregularity and deviation of the midline.

Key Words

Postretention • Relapse • Stability • Early orthodontic treatment • Late orthodontic treatment

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Table 1
Sample characteristics

	Early group		Late group		Pooled	
Gender						
Male	9		10		19	
Female	27		37		64	
Pool	36		47		83	
Angle Class						
Class I	13		23		36	
Class II Div. 1	20		18		38	
Class II Div. 2	3		6		9	
Age	Mean	SD	Mean	SD	Mean	SD
Pretreatment	11y 3m	(11.79m)	13y 4m	(15.05m)	12y 5m	(19.95m)
Posttreatment	14y 5m	(16.81m)	16y 3m	(17.06m)	15y 5m	(19.98m)
Postretention	30y 7m	(57.49m)	32y 0m	(59.84m)	31y 5m	(58.81m)
Postretention period	16y 2m	(57.63m)	15y 10m	(58.67m)	15y 11m	(59.90m)

Table 2
A comparison of early and late treatment groups for measurements at times T1, T2, and T3

Variable	Early group Av.	Early group S.D.	Late group Av.	Late group S.D.	Intergroup difference
Irregularity Index					
T1 (Pretreatment)	7.97	3.31	8.34	3.71	n.s.
T2 (Posttreatment)	1.55	1.39	1.39	0.84	n.s.
T3 (Postretention)	3.09	1.35	4.15	1.94	**
Arch length					
T1	56.43	4.06	54.67	5.15	n.s.
T2	48.24	2.24	47.83	2.86	n.s.
T3	44.88	5.02	44.54	4.01	n.s.
Canine width					
T1	25.99	2.23	24.84	2.49	*
T2	27.23	1.40	26.99	1.87	n.s.
T3	25.15	4.08	24.54	1.90	n.s.
Overbite					
T1	4.34	1.87	3.80	1.88	n.s.
T2	2.78	1.02	2.76	1.53	n.s.
T3	3.06	1.27	3.57	1.50	n.s.
Overjet					
T1	5.82	2.30	5.70	2.76	n.s.
T2	2.83	0.62	2.86	0.73	n.s.
T3	3.19	1.02	3.63	1.09	n.s.
Warp of midline					
T1	1.14	1.04	1.08	0.95	n.s.
T2	0.38	0.40	0.35	0.43	n.s.
T3	0.34	0.39	0.58	0.44	**

Student *t*-test, significance: *$p<0.05$, **$p<0.01$

were not included in this study. Patients were divided into two groups, based on whether orthodontic mechanical treatment was initiated in the mixed or permanent dentition (Table 1).

Subjects in the early (mixed dentition) orthodontic treatment group (Hellman's dental age III B,[20] n=36) still had at least one deciduous tooth, or did not have sequential teeth that were fully erupted at the start of treatment. Active orthodontic treatment was started during the mixed dentition immediately after extraction of first premolars. Serial extraction cases that had a period of physiologic drift after the extractions were excluded. All cases had early banding of molars and bonding of incisors to gain initial alignment. In a few cases, a lingual arch was used in the mandibular arch until the permanent teeth were fully erupted. Full orthodontic treatment plus retention followed this early alignment phase.

In the late (permanent dentition) orthodontic treatment group (Hellman's dental age III C[20] or after, n=47), all permanent teeth anterior to the second molars had erupted prior to treatment. The first premolars were extracted and active treatment was initiated immediately.

All Class II Division 1 and Class II Division 2 cases involved headgear therapy to the maxillary arch. In some of the cases, a maxillary bite plate was used for overbite reduction. Each patient had complete records, including dental casts and cephalometric radiographs, at three time periods (Table 1): pretreatment (T1), at the end of active treatment (T2), and a minimum of 10 years after removal of retainers (T3). All patients had undergone routine edgewise orthodontic treatment that included maxillary and mandibular first premolar extraction. All four premolars were extracted either before or soon after the start of initial treatment or, in a few cases, within 5 months after the initial active treatment. Treatment was followed by a variable period of retention, typically 1 to 3 years of a removable maxillary retainer and a mandibular canine-to-canine fixed retainer. None of the cases received a "sulcus slice" procedure (circumferential supracrestal fiberotomy) in an effort to avoid postretention rotation change. To be included in the sample, a clinically acceptable result at the end of active treatment had to have been achieved, with a full complement of teeth (excluding the extracted first premolars) anterior to the first permanent molars present at the postretention stage.

The average postretention period was 15 years for the early orthodontic treatment group and 16 years for the late orthodontic treatment group. There was no significant difference in the retention and posttreatment periods between the early and late orthodontic treatment groups.

To reduce examiner bias in the current study, each cast was measured in random order, with similar measurement errors as in previous research[11] (0.01 mm to 0.30 mm). A digital caliper (Caliper Ultra-Call Mark III, Fowler Co, Inc, Newton, Mass) was used to measure (at 0.01 mm) the following values for each set of cases.

Irregularity index: The summed displacement of the anatomic contact points of the lower anterior teeth as described by Little[19] (Figure 1A).

Mandibular arch length: The sum of the left and right distances from mesial anatomic contact points of the first permanent molars to the contact point of the central incisors (Figure 1B).[19]

Mandibular intercanine width: The distance between cusp tips or estimated cusp tips in cases of wear facets.

Overbite: Mean overlap of maxillary to mandibular central incisors.[21]

Overjet: The distance parallel to the occlusal plane from the incisal edge of the most labial maxillary incisor to the opposing mandibular central incisor.[21]

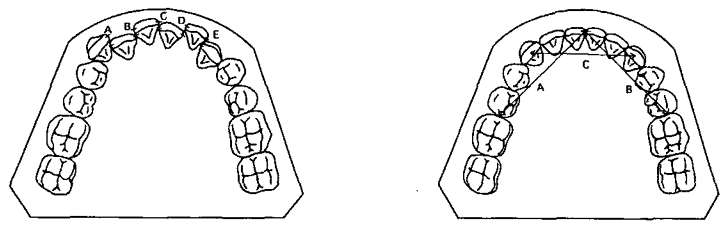
Deviation of the midline: The difference between maxillary and mandibular incisor midlines.

To assess measurement error, 23 dental casts were remeasured 2 weeks after the initial measurements were made. The mean errors in assessing irregularity index, arch width, arch length, overbite, overjet, and deviation of the midline ranged within 0.32 mm. Statistical analysis was performed using standard methods. Groups were compared by Student's t-test for independent groups, and the significance of changes across time was determined by the Student's t-test for paired data. Association between variables was evaluated by the Pearson product moment correlation coefficient. Statistical significance was established at $p < 0.05$, and a correlation of $r > 0.60$ was considered to have clinical importance.

Table 3
Comparison of early and late treatment groups for changes between time periods

Variable	Early group Av.	Early group S.D.	Late group Av.	Late group S.D.	Intergroup difference
Irregularity index					
T1-T2 (Treatment)	-6.42	3.18	-6.94	3.93	n.s.
T1-T3 (Overall)	-4.88	3.17	-4.19	4.06	n.s.
T2-T3 (Postretention)	1.53	1.14	2.75	1.95	**
Arch length					
T1-T2 (Treatment)	-8.19	3.41	-6.83	4.01	n.s.
T1-T3 (Overall)	-11.55	4.92	-10.13	3.50	n.s.
T2-T3 (Postretention)	-3.36	3.65	-3.29	2.15	n.s.
Canine width					
T1-T2 (Treatment)	1.16	2.04	2.15	1.90	n.s.
T1-T3 (Overall)	-0.31	1.87	-0.30	1.65	n.s.
T2-T3 (Postretention)	-1.48	1.21	-2.45	1.41	**
Warp of midline					
T1-T2 (Treatment)	0.77	1.10	0.73	1.06	n.s.
T1-T3 (Overall)	0.81	1.00	0.50	1.03	n.s.
T2-T3 (Postretention	0.04	0.42	-0.22	0.51	*

Student t-test, significance: *$p<0.05$, **$p<0.01$



A
A+B+C+D+E=irregularity index

B
A+B=arch length, C=canine width

Figure 1

Figure 1
Mandibular study models illustrating points to quantify irregularity index (A) as well as arch length and intercanine width (B).

Results

Mandibular irregularity index

The mean values observed at the three time periods are shown in Table 2. At pretreatment there were no statistically significant differences between groups (early: $\bar{x}$=7.97 mm, SD=3.31 mm; late: $\bar{x}$=8.34 mm, SD=3.71 mm). Both groups improved to acceptable levels by the end of treatment (early: $\bar{x}$ =1.55 mm, SD=1.39 mm;

Table 4
Comparison of subjects grouped by class for changes at T1, T2, and T3

	Class I N=36		Class II Div.1 N=38		Class II Div.2 N=9		Interclass difference		
	Av.	S.D.	Av.	S.D.	Av.	S.D.	(I)	(II)	(III)
Irregularity index									
T1 (Pretreatment)	8.18	3.59	8.01	3.23	8.87	4.55			
T2 (Posttreatment)	1.42	0.77	1.47	0.84	1.60	0.53			
T3 (Postretention)	3.41	1.68	3.88	1.82	3.97	2.11			
Arch length									
T1	54.88	4.34	56.91	4.43	51.64	5.51	*	**	
T2	48.09	2.94	48.07	2.49	46.85	2.28			
T3	45.16	3.39	44.98	4.28	43.16	2.70			
Canine width									
T1	25.67	2.27	25.26	2.42	24.36	3.10			
T2	27.17	1.81	27.00	1.71	26.92	1.54			
T3	25.19	1.79	24.97	2.24	24.74	2.55			
Overbite									
T1	3.18	1.65	4.33	1.65	6.16	1.69	**	**	**
T2	2.77	1.66	2.96	1.00	2.14	0.98	*		
T3	2.78	1.35	3.88	1.37	3.46	1.78	**		
Overjet									
T1	4.99	1.80	7.20	2.57	2.86	1.06	**	**	**
T2	2.76	0.58	3.09	0.68	2.27	0.65	*	*	**
T3	3.24	0.98	3.85	0.93	2.87	0.99	**	**	
Warp of midline									
T1	1.03	0.70	1.26	1.16	0.77	1.14			
T2	0.40	0.45	0.28	0.37	0.54	0.42			
T3	0.48	0.45	0.46	0.44	0.49	0.38			

1. (I):Class I vs. Class II Div. 1; (II):Class I vs. Class II Div. 2; (III):Class II Div. 1 vs. Class II Div. 2.
2. Student *t*-test, significance: *$p<0.05$, **$p<0.01$

late: $\bar{x}$ =1.39 mm, SD=0.84 mm) and there were no statistically significant differences between groups at the posttreatment stage. During the postretention period, both groups crowded to an extent. The differences were statistically significant between early and late orthodontic treatment groups (early: $\bar{x}$ =3.09 mm, SD=1.35 mm; late: $\bar{x}$ =4.15 mm, SD=1.94 mm, $p<0.01$). As noted in Table 3, during the postretention period (T2 to T3) there was a statistically significant difference between the early and late orthodontic treatment groups (early: $\bar{x}$ =1.53 mm, SD=1.14 mm; late: $\bar{x}$ =2.75 mm, SD=1.95 mm, $p<0.01$). However, during the overall period (T1 to T3) and the treatment period (T1 to T2), there were no statistically significant differences between the early and late orthodontic treatment groups. No gender differences were noted at any time or during any interval for either group.

The samples were divided by Angle classification (Table 4). In assessing the other dental parameters and the incisor irregularity index, some clinically useful correlations were noted. A very weak association existed between the postretention (T2 to T3) change of incisor irregularity and the time of initial orthodontic treatment in the Class II Division 1 group (r=0.43) and Class II Division 2 group (r=0.46). There was a tendency for early orthodontic treatment to yield less incisor irregularity in the Class II Division 1 and Division 2 groups. No associations were found in the Class I group.

Mandibular arch length

Mandibular arch length decreased in all instances during treatment because the sample consisted of patients who had four first premolars extracted. No significant difference was noted between the two groups in terms of either the degree of arch length change (T1 to T2, T1 to T3, and T2 to T3) or arch length at each time (T1, T2, and T3).

In assessing the other dental parameters and arch length, a weak association did exist between arch length at pretreatment (T1) and at

Table 5
Changes between time periods

	Class I N=36		Class II Div.1 N=38		Class II Div.2 N=9		Interclass difference		
	Av.	S.D.	Av.	S.D.	Av.	S.D.	(I)	(II)	(III)
Irregularity index									
T1-T2 (Treatment)	-6.75	3.72	-6.54	3.23	-7.27	4.73			
T1-T3 (Overall)	-4.77	4.10	-4.13	3.30	-4.90	3.85			
T2-T3 (Postretention)	1.99	1.55	2.41	1.81	2.38	2.27			
Arch length									
T1-T2 (Treatment)	-6.80	2.74	-8.85	3.81	-4.79	5.52	**	*	
T1-T3 (Overall)	-9.72	2.96	-11.93	4.70	-8.48	4.70	*		
T2-T3 (Postretention)	-2.92	1.84	-3.08	3.76	-3.69	2.16			
Canine width									
T1-T2 (Treatment)	1.50	1.74	1.74	2.15	2.56	2.45			
T1-T3 (Overall)	-0.48	1.82	-0.29	1.73	0.38	1.34			
T2-T3 (Postretention)	-1.98	1.42	-2.03	1.40	-2.18	1.50			
Warp of midline									
T1-T2 (Treatment)	-0.62	0.77	-0.98	1.22	0.23	1.31			
T1-T3 (Overall)	-0.55	0.72	-0.80	1.19	-0.28	1.27			
T2-T3 (Postretention)	0.08	0.43	0.18	0.52	-0.06	0.57			

1. I:Class I vs. Class II Div. 1; II:Class I vs. Class II Div. 2; III:Class II Div. 1 vs. Class II Div. 2.
2. Student *t*-test, significance: *$p<0.05$, **$p<0.01$

postretention (T3) (r=0.54) and also between arch length at pretreatment and mandibular intercanine width at pretreatment (r=0.58). No gender differences were noted in mandibular arch length at any time or during any interval for either sample group.

Dividing the sample by Angle classification, statistically significant differences existed in mandibular arch length at pretreatment. The arch lengths of Class II Division 2 cases were significantly smaller than those of the other groups. However, no differences were noted at posttreatment (T2) or postretention (T3) for either sample group.

Mandibular intercanine width

At pretreatment there was a statistically significant difference in mandibular intercanine width between groups (early: $\bar{x}$ =25.99 mm, SD=2.23 mm; late: $\bar{x}$ =24.84 mm, SD=2.49 mm, $p<0.05$). This width had increased in both groups by the end of treatment (early: $\bar{x}$ =27.23 mm, SD=1.40 mm; late: $\bar{x}$ =26.99 mm, SD=1.87 mm). But during the postretention period, width decreased in both groups (early: $\bar{x}$ =25.15 mm, SD=4.08 mm; late: $\bar{x}$ =24.54 mm, SD=1.90 mm, $p<0.05$) and the difference was statistically significant. Considering the change in canine width during the postretention period, there was a statistically significant difference between the early and late orthodontic treatment groups (early: $\bar{x}$ =-1.48 mm, SD=1.21 mm; late: $\bar{x}$ =-2.45 mm, SD=1.41 mm, $p<0.05$). In assessing other dental parameters and mandibular intercanine width, some clinically useful correlations were found. In both groups, a moderate association existed between canine width at pretreatment (T1) and at posttreatment (T2) (r=0.58). A moderate association existed between canine width at pretreatment (T1) and at postretention (T3) (r=0.71). Also, a moderate association existed between canine width at posttreatment (T2) and at postretention (T3) (r=0.74).

The samples were divided by Angle classification and gender. No differences were noted in mandibular canine width at any time nor at any interval for either sample group.

Overbite

There was no statistically significant difference between groups at pretreatment (early: $\bar{x}$=4.34 mm, SD=1.87 mm; late: $\bar{x}$=3.80 mm, SD=1.88 mm), or by the end of treatment (early: $\bar{x}$=2.78 mm, SD=1.02 mm; late: $\bar{x}$ =2.76, mm, SD=1.53 mm), or at postretention (early: $\bar{x}$=3.06 mm, SD=1.27 mm; late: $\bar{x}$=3.57 mm, SD=1.50 mm). In both groups, a weak association existed between overbite at pretreatment (T1) and at postretention (T3) (r=0.45) and between overbite and overjet at postretention (T3) (r=0.44). No gender differences were noted in overbite at any time or at any interval for either sample group.

Overjet

No significant difference was noted between the two groups in terms of either the degree of overjet change (T1 to T2, T1 to T3, and T2 to T3) or overjet at each time (T1, T2, and T3). In assessing the other dental parameters and overjet,

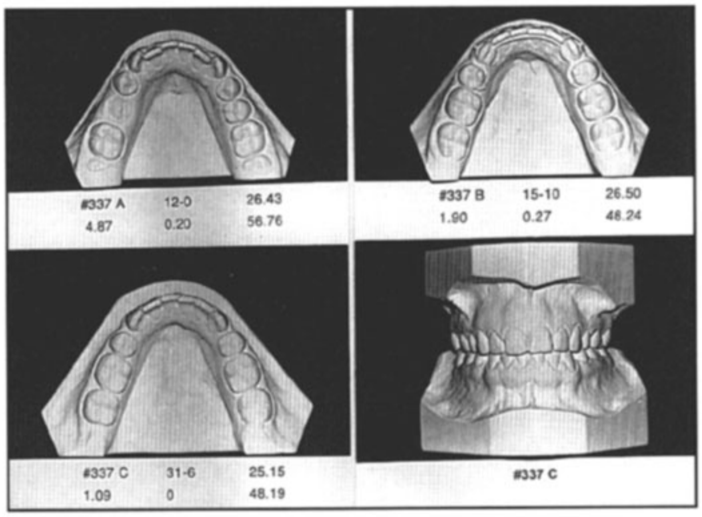


Figure 2

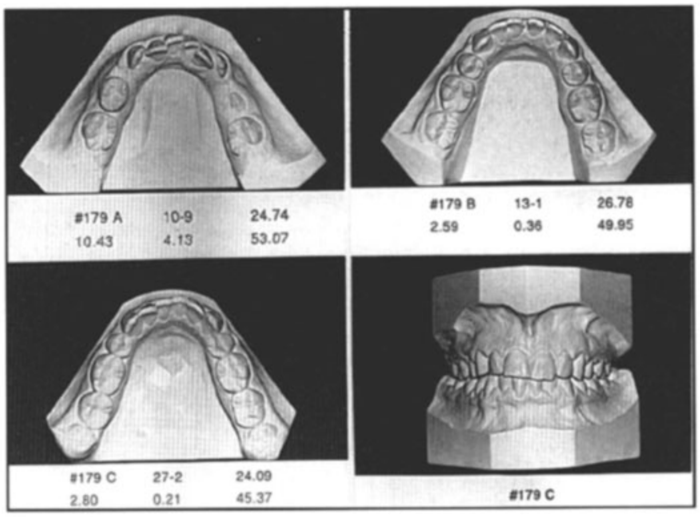


Figure 3

Figures 2 and 3
Early (mixed dentition) orthodontic treatment group cases:
Data represent case number, age, irregularity index, arch length, intercanine width, and warp of midline.
A. Pretreatment
B. Posttreatment
C. Postretention

some clinically useful correlations were found. A moderate association existed between the overjet at pretreatment (T1) and at postretention (T3) (r=0.56). No gender differences were noted in overjet at any time or at any interval for either sample group.

Deviation of the midline

At pretreatment there was no statistically significant difference between groups (early: $\bar{x}$=1.14 mm, SD=1.04 mm; late: $\bar{x}$=1.08 mm, SD=0.95 mm). Both groups improved by the end of treatment (early: $\bar{x}$=0.38 mm, SD=0.40 mm; late: $\bar{x}$=0.35 mm, SD=0.43 mm) and there was no statistically significant difference between the groups at posttreatment. During the postretention period, midline deviation continued to reduce in the early group, but it increased in the late group. The differences were statistically significant between early and late orthodontic treatment groups at postretention (early: $\bar{x}$=0.34 mm, SD=0.39 mm; late: $\bar{x}$=0.58 mm, SD=0.44 mm). A weak association existed between the deviation of the midline at postretention (T3) and at the time of initial orthodontic treatment (r=0.32). The time of initial orthodontic treatment was a weak predictor of long-term midline discrepancy. The samples were divided by Angle classification and gender but no differences were noted.

Case examples

Several typical cases help illustrate the variation in response.

Figure 2, Case #337

This mixed dentition early mechanical treatment case showed a very stable, excellent result at 12 years postretention. Intercanine width increased slightly during treatment. Intercanine width and arch length decreased slightly postretention. Overbite and overjet changed slightly postretention, but were considered clinically acceptable.

Figure 3, Case #179

This crowded case was typical of the average postretention relapse in the mixed dentition group. Intercanine width increased slightly during treatment. Intercanine width and arch length decreased slightly postretention. Overbite and overjet remained relatively stable postretention.

Figure 4, Case #062

In spite of an excellent treatment result, this case demonstrated the greatest anterior alignment relapse of the late group. Intercanine width and arch length decreased greatly during postretention. Overbite, overjet, and midline deviation increased markedly postretention.

Figure 5, Case #006

This severely crowded case was typical of the average postretention relapse noted in the late group. Intercanine width increased slightly during treatment. Intercanine width and arch length decreased slightly postretention. Overbite and overjet changed slightly postretention, but were considered clinically acceptable.

A significant difference was found between early and late groups in the mean of the irregularity index, but there was great variation of individual cases, with both groups having examples of success and failure.

Discussion

The quandary faced by clinicians is how to best deal with the patient demonstrating significant pretreatment crowding. Assuming an anterior arch length shortage at the time of initial orthodontic treatment, will long-term stability be better if alignment is accomplished during the mixed dentition or should one delay initial orth-

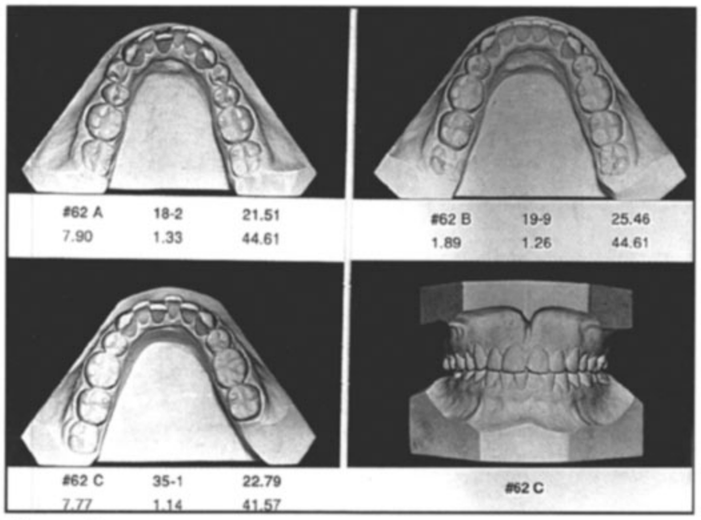


Figure 4

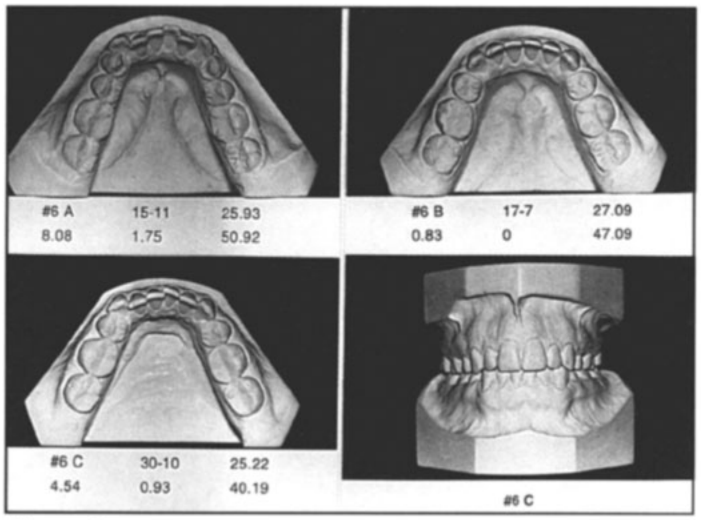


Figure 5

Figures 4 and 5
Late (permanent dentition) orthodontic treatment group cases: Data shown represent case number, age, irregularity index, arch length, intercanine width, and warp of midline.
A. Pretreatment
B. Posttreatment
C. Postretention

odontic treatment until the permanent dentition has fully erupted? One could argue that early treatment may lessen the severity of the problem, lessen possible periodontal complications from ectopic eruption of teeth, and shorten the eventual treatment time. But what about stability?

Several authors have suggested that early orthodontic treatment followed by retention yields improved stability. Lee and Dugoni[22,23] emphasized in their treatment case reports that early orthodontic treatment produced more stable long-term orthodontic results, although no scientific data or evidence was presented to substantiate this claim. In a later study of nonextraction cases, Dugoni et al.[24] concluded that early mixed dentition treatment using leeway space to unravel lower incisor crowding may yield improved mandibular incisor stability. Rondeau[25] stated that early orthodontic treatment can correct the existing muscular, skeletal, and dental imbalances and thereby improve stability. However, this article was written from clinical experience and from research investigations using adolescent monkeys. In an interview, Ricketts[26] recommended early orthodontic treatment except in Class III patients, but no evidence was offered. Tweed,[27,28] Dewel,[29,30] Mayne,[31] and Dale[32] have also suggested the benefits of early orthodontic treatment, but all were statements of clinical opinion without the backing of postretention records.

In contrast to our previous studies, the current data demonstrates that early orthodontic treatment of crowded first premolar extraction cases is somewhat more stable than later treatment. Little, Riedel, and Engst,[8] in a study of first premolar serial extraction, showed results no better than previous studies of late extraction followed by treatment.[4] To resolve these inconsistencies, serial extraction cases were excluded from the current study. All early treatment cases involved fixed appliances to align incisors. These early treated cases showed better success than cases of serial extraction followed by physiologic drift, as previously reported.[8] Perhaps the key to improved stability is early extraction plus anterior alignment, rather than early extraction followed by physiologic drift and mere observation.

Similar to the findings of Little, Riedel, and Engst,[8] McReynolds and Little[13] also had a "no difference" finding when comparing serial extraction versus late extraction of mandibular second premolars followed by routine treatment. In the current study, all early treatment cases involved fixed appliances to align incisors. The serial extraction cases of McReynolds' study had no early mechanical therapy. The increased sample size in the current study may further account for these differences—the McReynolds' study had only 14 early extraction cases.

In the current study, the mean irregularity index at postretention of the early orthodontic treatment cases ($\bar{x}$=3.09 mm, SD=1.35 mm) was clinically better than that of the late orthodontic treatment cases ($\bar{x}$=4.15 mm, SD=1.94 mm). However, the very weak correlation between postretention irregularity and the time of initial orthodontic treatment (r=.24) demonstrates the marked variation of the sample.

Another interesting finding was the significantly better postretention midline relationship of early orthodontic treatment cases. The mean deviation of the midline at postretention of the early orthodontic treatment cases ($\bar{x}$=0.34 mm, SD=0.39 mm) was clinically much better than that of the late orthodontic treatment cases ($\bar{x}$=0.58 mm, SD=0.44 mm). The weak correlation between the midline deviation at postretention and the time of initial orthodontic treatment (r=.32) again demonstrates the marked variation of the sample.

The findings of this study suggest that early orthodontic anterior alignment of crowded first premolar extraction cases may be justified in order to reduce postretention mandibular incisor irregularity.

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